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(54) Variable cam timing system and method

(57) An apparatus and method for supplying pressurised fluid to a variable cam timing phasing unit. A bearing is secured to the engine for rotatably supporting the cam shaft. The bearing has an inlet for pressurised fluid and a pair of outlets for the pressurised fluid. One of the outlets is associated with relatively advancing cam timing and the other of the outlets is associated with relatively retarding cam timing. A solenoid valve selectively routes pressurised fluid between the inlet and one of the outlets.

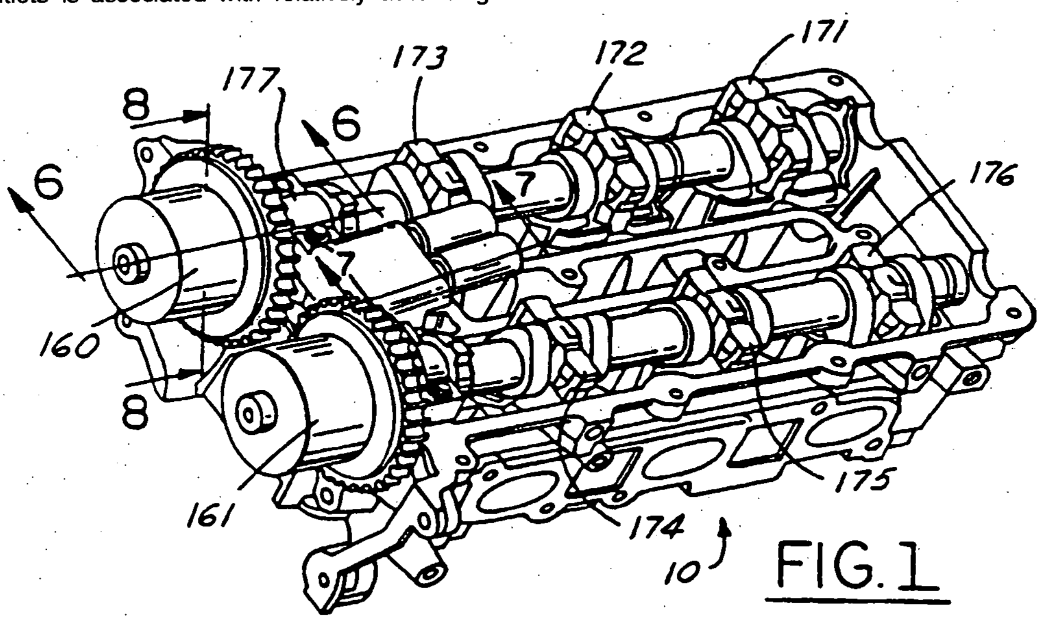

FIG. 1

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Description

[0001] The present invention relates to a system and method for use in a variable cam timing system to provide pressurised fluid to a phaser unit to control variable cam timing for an internal combustion engine.

[0002] Conventional engines maintain a fixed relationship between camshaft rotation and crankshaft rotation, thereby preserving the relationship between intake and exhaust valve events and piston motion. Alternatively, so called variable cam timing engines utilise a mechanism for adjusting this relationship for various advantages related to increased fuel economy and reduced regulated emissions.

[0003] To realise these benefits an apparatus must be provided to control the cam timing. One known method of controlling variable cam timing is now described. First, the actual cam timing is measured using a toothed wheel on the camshaft and a toothed wheel on the crankshaft. The time, or angle, between receiving pulses from the wheel on the crankshaft and the wheel on the camshaft represents the actual cam timing. Second, a desired cam timing is determined as a function of engine operating conditions. Third, an error signal is created from the difference of the desired cam timing and the actual cam timing. Fourth, control signals based on the error signal are sent to actuators capable of adjusting the cam timing. Such a system is disclosed in U.S. 5,363,817.

[0004] In such a system, the cylinder heads are designed for variable cam timing; i.e. the heads include oil porting passages to communicate pressurised oil to a solenoid valve, which directs the pressurised oil to a selected passage in the cam shaft, which directs the pressurised fluid of the cam phaser.

[0005] US Patent 5,657,725, which is incorporated herein by reference, describes a VCT system utilising engine oil pressure for actuation. This system provides limited detail of how the oil is delivered from the spool valve assembly 192 housed in the camshaft 126, other than stating the oil is delivered to the recesses 131, 132 through hydraulic lines 101 or 102 (ref column 5, lines 1-20). It is unclear how these lines communicate to the phaser units (which rotate with the camshaft), unless the lines 101 or 102 are formed within the camshaft in a known manner. Otherwise, the lines 101, 102 create additional parts and potential packaging and reliability issues. In either case, extensive work is required to get the spool valve 192 within the camshaft and to get the oil to the valve 192 and to the phaser units.

[0006] US patent 5,119,691 describes, with reference to Figure 6, a bearing 132 having passageways therethrough for communicating oil between a remote solenoid valve 128 and a groove 137 in a camshaft 136. In this design, the bearing 132 is a radial bearing and supports no axial loads nor does it support the solenoid 128. Therefore, this design requires extensive oil routing tubes and supports for the VCT actuation members.

[0007] These systems require extensive design considerations and machining of the heads and camshaft to accommodate the oil passages, as well as consideration to the mounting of the solenoid valves. It would be desirable to provide a simplified oil distribution system and particularly such a system which may be added to an existing engine and at minimal cost.

[0008] An object of the invention claimed herein is to provide a system and method for providing a simplified oil distribution system for a VCT system, and particularly such a system which may be added to an existing engine architecture.

[0009] The above object is achieved and disadvantages of prior approaches overcome by a system and method for supplying pressurised fluid to a variable cam timing phasing unit. A bearing is secured to the engine for rotatably supporting the cam shaft. The bearing has an inlet for pressurised fluid and a pair of outlets for the pressurised fluid. One of the outlets is associated with relatively advancing cam timing and the other of the outlets is associated with relatively retarding cam timing. A solenoid valve selectively routes pressurised fluid between the inlet and one of the outlets.

[0010] An advantage of the above aspect of the invention is improved oil distribution.

[0011] Another, more specific, advantage of the present inventions is the potential to add a VCT system to an existing engine architecture with minor changes.

[0012] Another advantage of the above aspect of the invention is reduced cost and time required to implement a VCT system.

[0013] Other objects, features and advantages of the present invention will be readily appreciated by the reader of this specification.

[0014] The object and advantages described herein will be more fully understood by reading an example of an embodiment in which the invention is used to advantage, referred to herein as the Description of the Preferred Embodiment, with reference to the drawings wherein:

Figure 1 is a schematic representation of an engine according to the present invention;

Figure 2 is a schematic representation of the engine of Figure 1 with the oil distribution system exploded therefrom;

Figure 3 is a bottom view of a cam bearing assembly according to the present invention;

Figure 4 is an isometric bottom view of an alternate embodiment of a cam bearing according to the present invention;

Figure 5 is a rear view of the cam bearing assembly of Figure 4;

Figure 6 is a representative cross sectional view of a shaft and bearing according to the present invention; and

Figure 7 is a representative cross sectional view of a valve according to the present invention; and

Figure 8 is a representative end view of a vane-type VCT phaser; and

Figure 9 is a schematic representation of an engine using a VCT according to the present invention.

[0015] As shown in Figure 9, an internal combustion engine 10, comprising a plurality of cylinders, one cylinder of which is shown in Figure 1, is controlled by electronic engine controller 12. Engine 10 includes combustion chamber 30 and cylinder walls 32 with piston 36 positioned therein and connected to crankshaft 40. Combustion chamber 30 is shown communicating with intake manifold 44 and exhaust manifold 48 via intake valve 52 and exhaust valve 54, respectively. Intake manifold 44 is shown communicating with throttle body 58 via throttle plate 62 Throttle position sensor 69 measures position of throttle plate 62. Exhaust manifold 48 is shown. Intake manifold 44 is also shown having fuel injector 80 coupled thereto for delivering liquid fuel in proportion to the pulse width of signal FPW from controller 12. Fuel is delivered to fuel injector 80 by a conventional fuel system (not shown) including a fuel tank, fuel pump, and fuel rail (not shown). Alternatively, the engine may be configured such that the fuel is injected directly into the cylinder of the engine, which is known to those skilled in the art as a direct injection engine.

[0016] Conventional distributorless ignition system 88 provides ignition spark to combustion chamber 30 via spark plug 92 in response to controller 12. Two-state exhaust gas oxygen sensor 16 is shown coupled to exhaust manifold 48 upstream of catalytic converter 97. Sensor 16 provides signal EGO to controller 12 which converts signal EGO into two state signal EGOS. A high voltage state of signal EGOS indicates exhaust gases are rich of a reference air fuel ratio and a low voltage state of converted signal EGO indicates exhaust gases are lean of the reference air fuel ratio

[0017] Controller 12 is shown in Figure 1 as a conventional microcomputer including microprocessor unit 102, input/output ports 104 read only memory 106, random access memory 108 and a conventional data bus. Controller 12 is shown receiving various signals from sensors coupled to engine 10, in addition to those signals previously discussed including: engine coolant temperature (ECT) from temperature sensor 112 coupled to cooling sleeve 114, a measurement of mass air flow measurement (MAF) from mass flow sensor 116 coupled to intake manifold 44; and a profile ignition pickup signal (PIP) from Hall effect sensor 118 coupled to crankshaft 40. In a preferred aspect of the present invention, engine speed sensor 119 produces a predetermined number of equally spaced pulses every revolution of the crankshaft.

[0018] Camshaft 130 of engine 10 is shown communicating with rocker arms 132 and 134 for actuating intake valve 52 and exhaust valve 54. Camshaft 130 is directly coupled to housing 136. Housing 136 forms a toothed wheel having a plurality of teeth 138. Housing 136 is hydraulically coupled to an inner shaft (not shown), which is in turn directly linked to camshaft 130 via a timing chain (not shown). Therefore, housing 136 and camshaft 130 rotate at a speed substantially equivalent to the inner camshaft. The inner camshaft rotates at a constant speed ratio to crankshaft 40. However, by manipulation of the hydraulic coupling as will be described later herein, the relative position of camshaft 130 to crankshaft 40 can be varied by hydraulic pressures in advance chamber 142 and retard chamber 144, as better illustrated in Figure 8. By allowing high pressure hydraulic fluid to enter advance chamber 142, the relative relationship between camshaft 130 and crankshaft 40 is advanced. Thus, intake valve 52 and exhaust valve 54 open and close at a time earlier than normal relative to crankshaft 40. Similarly, by allowing high pressure hydraulic fluid to enter retard chamber 144, the relative relationship between camshaft 130 and crankshaft 40 is retarded. Thus, intake valve 52 and exhaust valve 54 open and close at a time later than normal relative to crankshaft 40.

[0019] Teeth 138, being coupled to housing 136 and camshaft 130, allow for measurement of relative cam position via cam timing sensor 150 providing signal VCT to controller 12. Teeth 1, 2, 3, and 4 are preferably used for measurement of cam timing and are equally spaced (for example, in a V-8 dual bank engine, spaced 90 degrees apart from one another) , while tooth 5 is preferably used for cylinder identification, as described later herein. In addition, Controller 12 sends control signals (LACT,RACT) to conventional solenoid valves (not shown) to control the flow of hydraulic fluid either into advance chamber 142, retard chamber 144, or neither.

[0020] Relative cam timing is measured using the method described in U.S. 5,548,995, which is incorporated herein by reference. In general terms, the time, or rotation angle between the rising edge of the PIP signal and receiving a signal from one of the plurality of teeth 138 on housing 136 gives a measure of the relative cam timing. For the particular example of a V-8 engine, with two cylinder banks and a five toothed wheel, a measure of cam timing for a particular bank is received four times per revolution, with the extra signal used for cylinder identification.

[0021] As shown in Figure 1, engine includes a pair of camshafts 129, 130. Each camshaft is drivably connected to a phaser unit 160, 161 as described above with reference to Figure 9. As illustrated here, phaser units 160, 161 are illustrated as vane-type VCT phasers. One skilled in the art alternatively appreciates the applicability of the present invention to any other hydraulically actuated VCT unit, such as a piston unit, as described in US Patent 5,002,023. All such hydraulic units have not been described herein in detail, but in skilled in the art readily appreciates the applications of the present invention to these designs.

[0022] The camshafts 129, 130 are rotationally held in position by a number of bearings 171, 172, 173, 174,

175, and 176, which are well known to one skilled in the art. Additionally a bridge 177 holds both camshafts 129, 130 for rotation and against axial loading. As shown in Figure 2, bridge 177 is secured to the engine 10 using four bolts 180, 181, 182, 183 into tapped holes (not shown).

[0023] As shown in Figure 3, the bridge 177 includes a plurality of holes and conduits for communicating pressurised fluid. A first hole 190 receives pressurised fluid from a supply provided in the engine 10. As known to one skilled in the art, the supply preferably comprises a hole provided in the engine head. The first hole 190 communicates fluid to a pair of ports 191, 192 in fluid communication with a pair of solenoid valves 184, 185. The solenoids 184, 185 are held by the bridge 177 in a known manner. The valves 184, 185 (one of which 184 is shown in a partially unassembled state) include a plurality of annular grooves 186, 187 for communicating fluid from the ports 191, 192 through the bridge 177. The valves 184, 185 also include grooves 188 for o-ring seals as known to one skilled in the art. The valves 184, 185 are electrically operated and positionable to at least two positions to communicate the fluid to a pair of outlet ports 193, 194 or 195, 196, respectively. One skilled in the art appreciates the solenoid valve may have an intermediate position where either both or neither of the output ports communicate fluid, in order to hold the VCT in a desired position.

[0024] As shown in Figures 1-3, the solenoids 184, 185 are held nearly horizontally, or nearly parallel to the camshaft. This minimises the vertical package height required by this assembly. One skilled in the art appreciates that this orientation may be altered as package space best permits.

[0025] As shown in Figures 6 and 7, the spool 610 of the solenoid valve includes a number of lands 612, 614, 616, 618 for controlling the flow of fluid through the bridge 177'. The bridge 177' represented here is shown schematically to illustrate the communication across the spool 610 to a shaft 620 (shown in Figure 6). As noted above, the bridge 177' includes a number of outlet ports, two of which 693, 694 are represented here. The outlet ports communicate with one of a pair of advance and retard fluid passageways 621, 622, respectively formed in the shaft 620. The passageways 621, 622 then communicate the pressurised fluid through the camshaft 620 to the phaser units 160, 161 in a manner known to one skilled in the art to actuate an angular rotation thereof. As shown in Figure 7, pressurised oil is fed to the valve 184 from the cylinder head 710 through a pressurised oil feed port 712 preferably provided in the cylinder head or alternatively through an oil supply line external tot the head (not shown).

[0026] As shown in Figure 6, the bridge 177' includes a thrust bearing, which comprises an annular slot 630 formed in the bridge 177' and engages a flange 624 provided on the shaft 620. Thus, the bridge 177' acts as a thrust bearing for the shaft 620.

[0027] In an alternative embodiment, as shown in Figures 4-5, the bridge 177" includes a pair of substantially vertical solenoid valves 184', 185'. This bridge 177" includes a pair of oil grooves 693', 694' similar to the grooves 693, 694 of Figure 3, for communicating the oil to the shaft 620. This bridge 177" includes an oil inlet 190, communicating to the solenoid valves through bores formed in the bridge 177' and not shown here for the sake of clarity. As appreciated by one skilled in the art, this embodiment includes passageways formed internally thereto, and thus the mating of the bridge 177" to the head does not serve all of the sealing functions of the embodiment illustrates in Figures 2-3. The solenoid valves 184', 185' are then actuated in a known manner to control the flow of oil to one of two passages per valve and thus pressurise a select one of the grooves 693', 694' to communicate with the shaft.

[0028] As shown in Figure 7, in an alternative embodiment a sensor 150' may be mounted to the bridge 177" to detect teeth or notches formed on a member rotating with the camshaft, and thereby eliminate the need for additional bracketry for this sensor 150'. Although not shown here, in an alternative embodiment, the sensor 150' is mounted through the bridge 177' and teeth or notches (not shown) are formed on the flange 624 of the shaft 620, and the sensor 150' senses these the teeth on the flange 624.

[0029] As shown in Figure 5, the solenoid valves may include a flange 530 for a screw connection to the bridge 177' or may have a snap fit or threaded fit (not shown) to the bridge 177' as known to one skilled on the art. One skilled in the art also appreciates the present invention may be applied to a single camshaft, but optimally the bridge rotatably supports two camshafts to reduce the number of parts required.

[0030] While the best mode for carrying out the invention has been described in detail, those skilled in the art in which this invention relates will recognise various alternative designs and embodiments, including those mentioned above, in practising the invention that has been defined by the following claims.

Claims

1. An apparatus for supplying pressurised fluid to a variable cam timing phasing unit rotatably coupled to a cam shaft of an engine, the apparatus comprising:

    a bearing secured to the engine for rotatably supporting the cam shaft, the bearing having an inlet for pressurised fluid and a pair of outlets for the pressurised fluid, one of the outlets associated with relatively advancing cam timing and the other of the outlets for relatively retarding cam timing; and

    a solenoid valve for selectively routing pressurised fluid between the inlet and one of the out-

lets.

2. A fluid supply apparatus according to claim 1, wherein said bearing supports a second cam shaft and said bearing further comprises a second pair of outlets for the pressurised fluid, one of the second pair of outlets associated with relatively advancing cam timing of the second cam shaft and the other of the second outlets for relatively retarding cam timing of the second shaft.

3. A fluid supply apparatus according to claim 1, wherein the bearing further comprises an annular groove for supporting said cam shaft axially against thrust loads.

4. A fluid supply apparatus according to claim 2, wherein the bearing further comprises a pair of annular grooves for supporting said cam shafts axially.

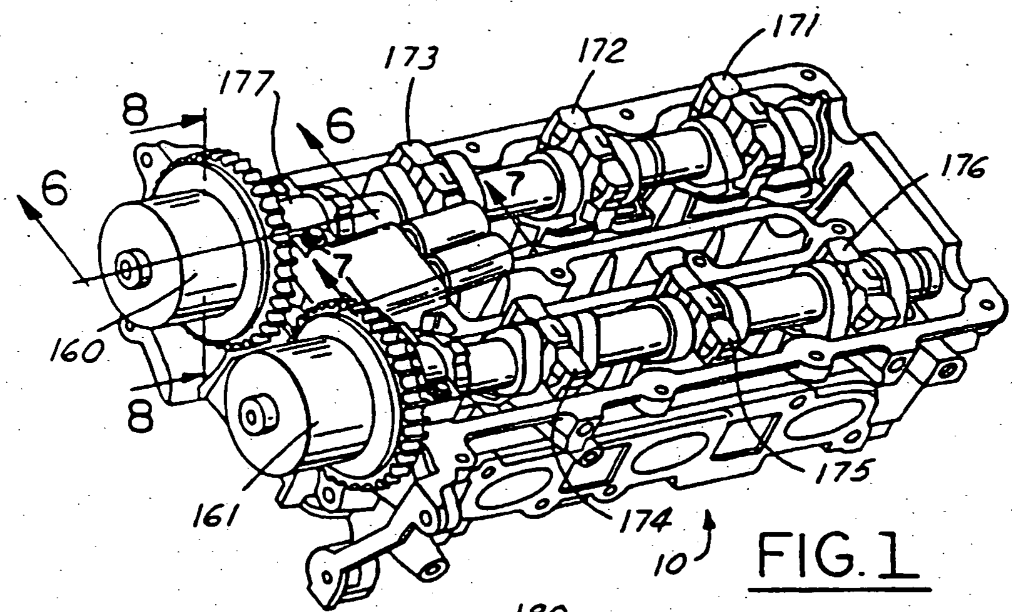
5. A fluid supply apparatus according to any preceding claim, further comprising a cam timing sensor mounted to said bearing for sensing a rotation of the cam shaft.

6. The fluid supply apparatus according to Claim 5 wherein said sensor generates a signal in response to a rotation of a toothed wheel coupled to the camshaft.

7. A fluid supply apparatus according to any preceding claim, further comprising a pair of fluid conduits formed in the bearing for communicating fluid from the solenoid to a respective one of the outlets.

8. A fluid supply apparatus according to claim 8, wherein said bearing further comprises a support for said solenoid, said solenoid communicating fluid internal to the bearing to selectively route fluid to a selected one of said outlets.

9. An apparatus as claimed in any preceding claim for supplying pressurised fluid to a pair of variable cam timing phasing units rotatably coupled to a pair of cam shafts of an internal combustion engine.


171
172
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177
8
6
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176
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174
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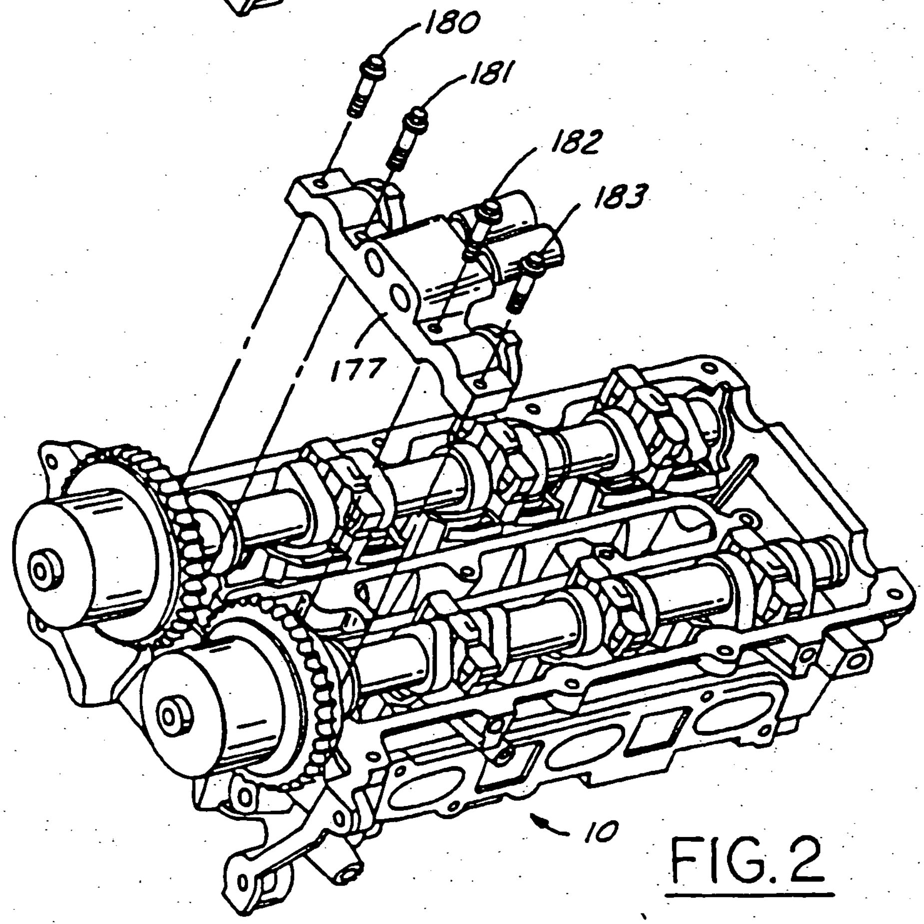
FIG. 1


180
181
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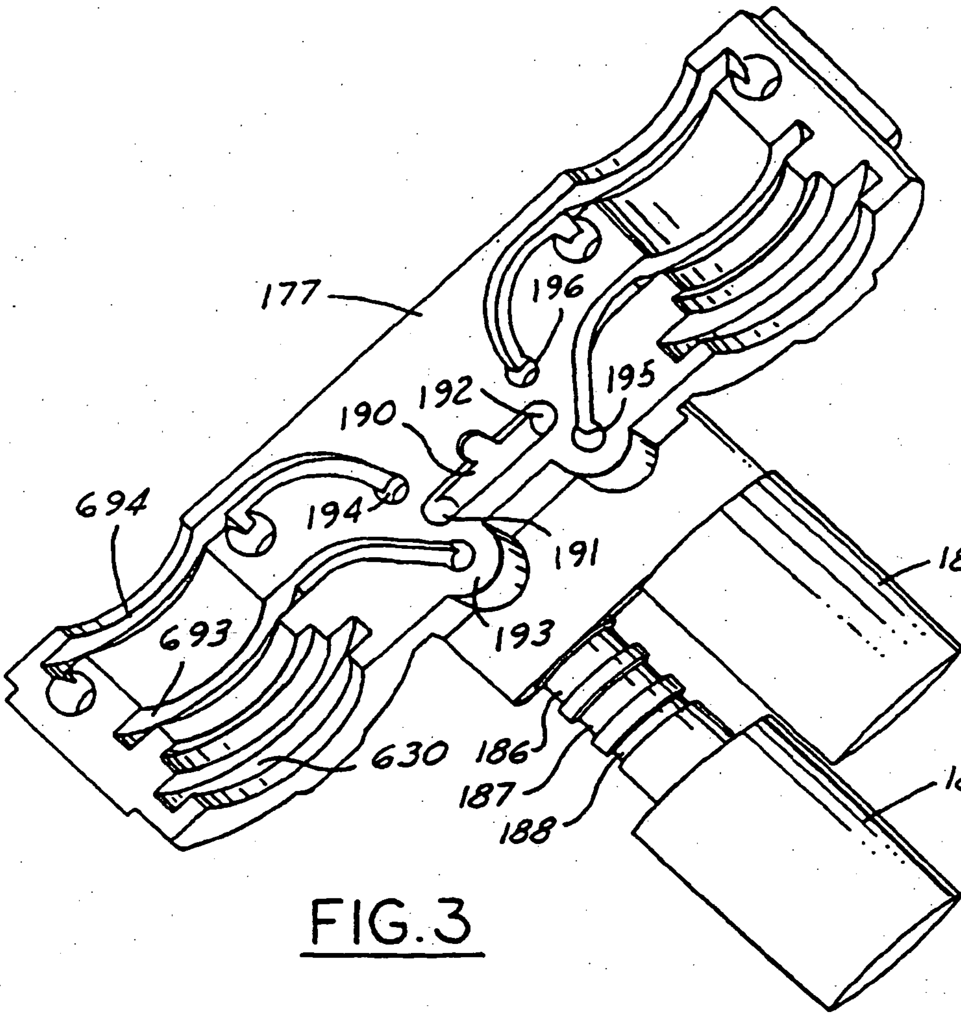
183
177
10

FIG. 2


177
196
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191
185
693
193
630
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187
184
188

FIG.3

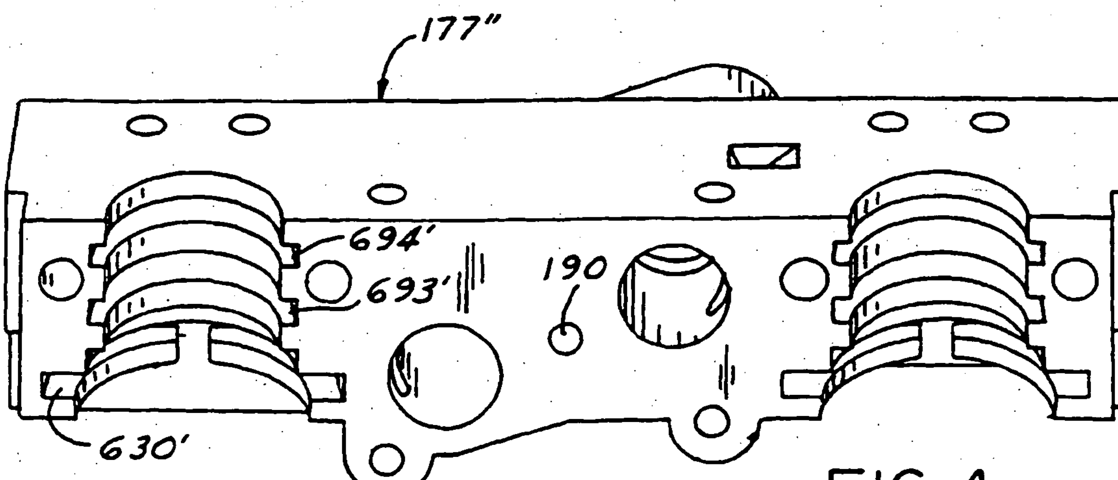

177"
694'
693'
190
630'

FIG.4

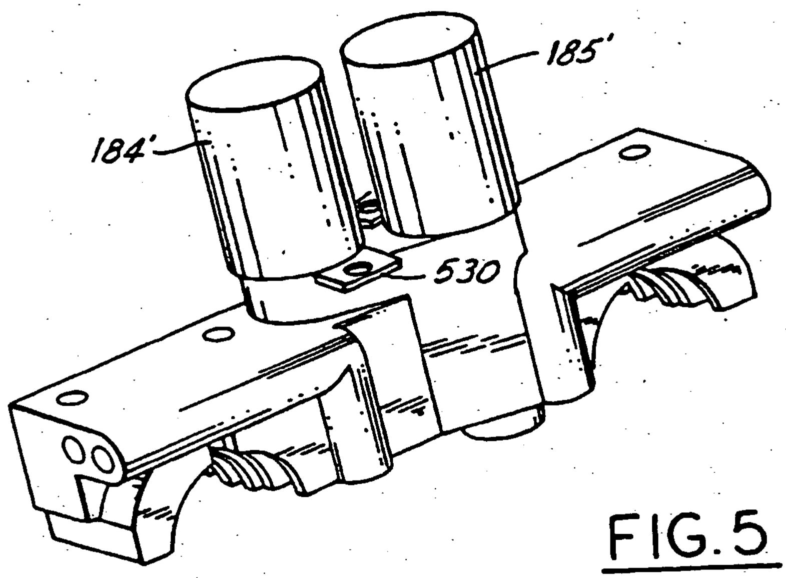


FIG.5

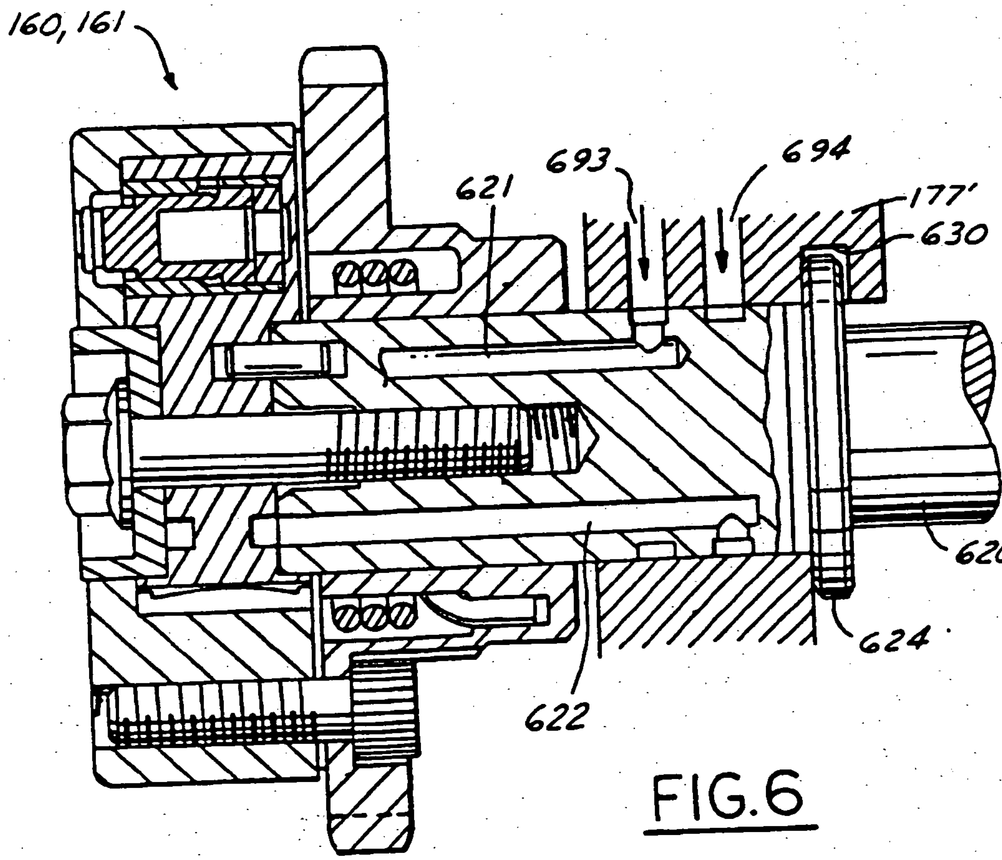


FIG.6

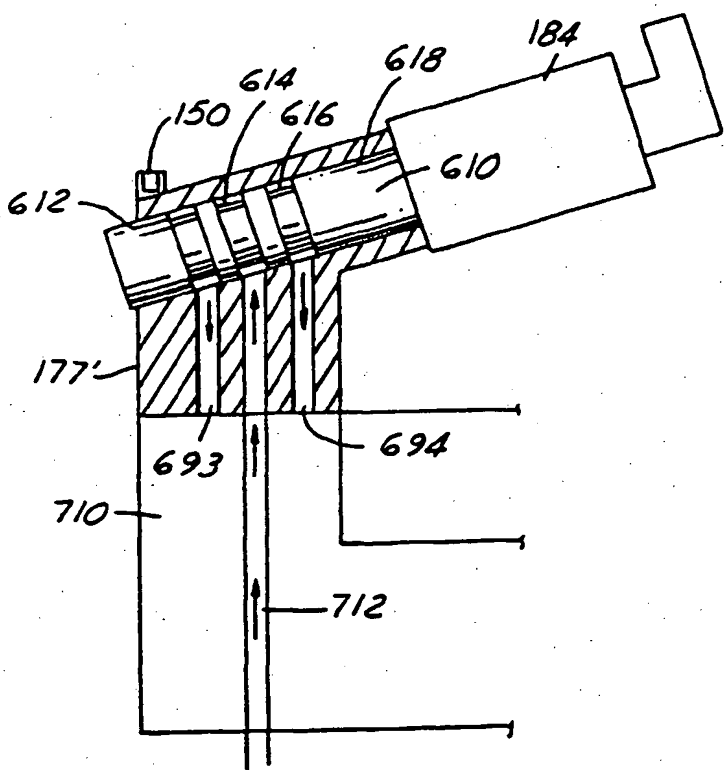


FIG.7

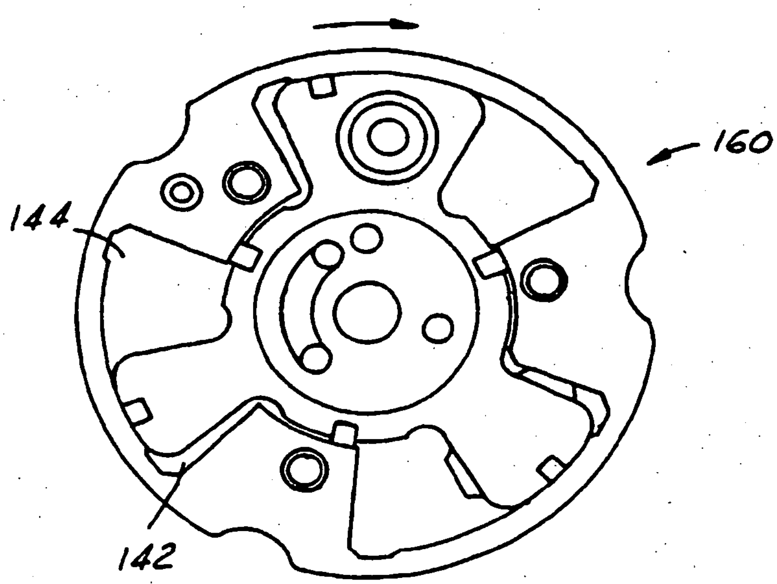
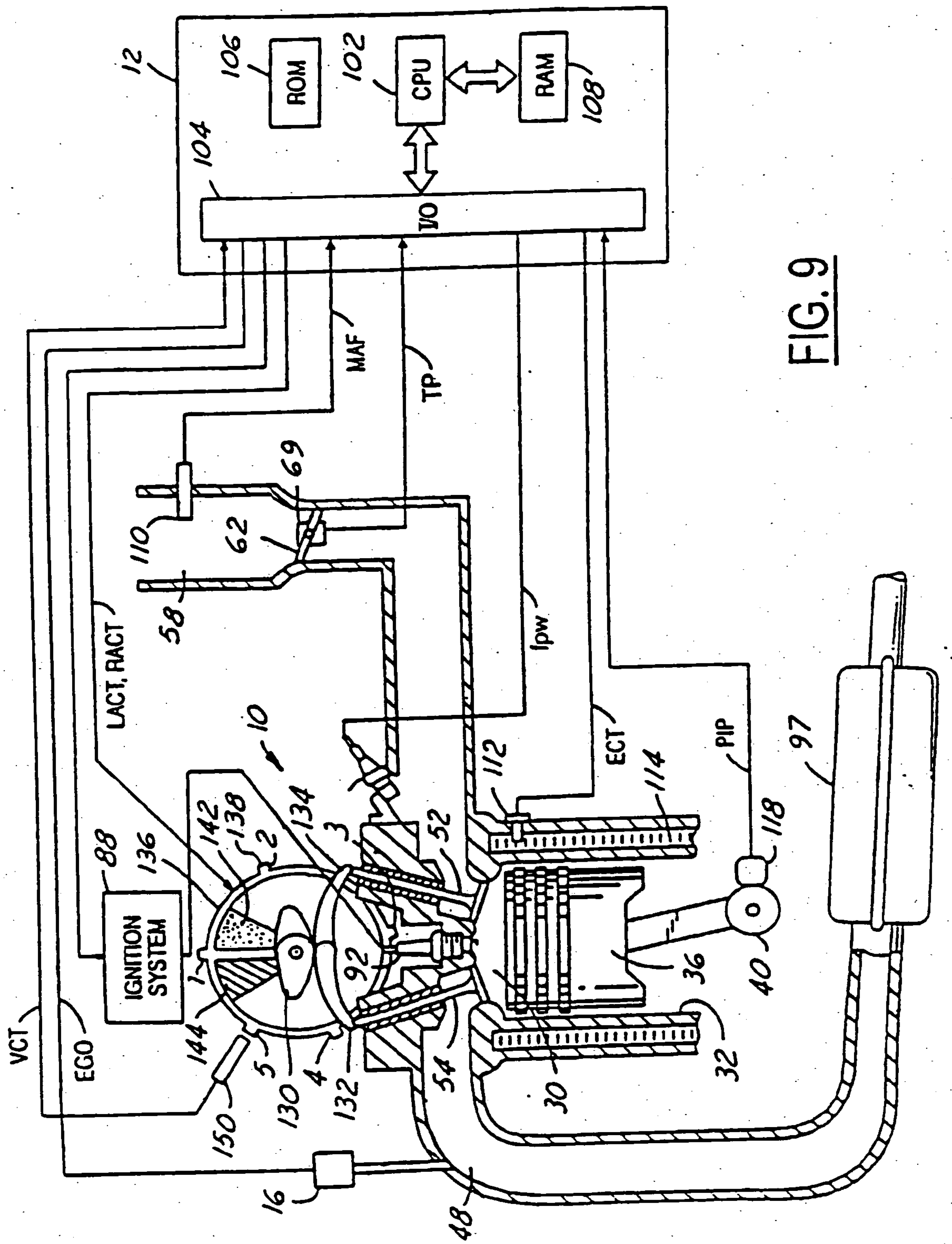


FIG.8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112
114
118
97
136
142
138
2
134
3
52
92
36
40
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144
5
130
4
132
54
30
32
150
16
48

FIG. 9

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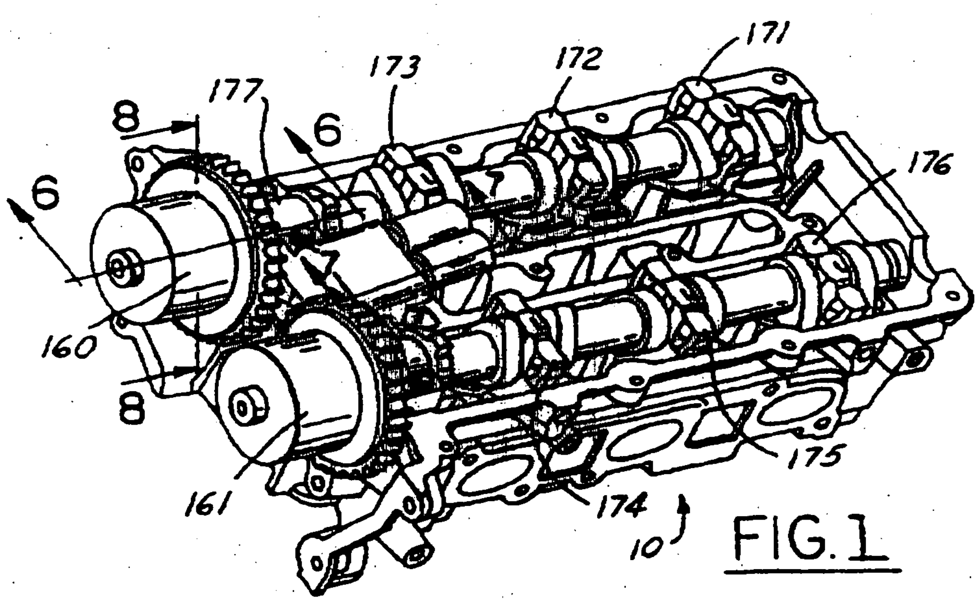

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 2306

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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F01L
F01M
F02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	21 June 2002	Paulson, B

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 2306

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

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MUNICH	21 June 2002	Paulson, B

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